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(54) **HEAT PUMPS**

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Description

[0001] This invention relates to heat pumps of the absorption cycle type, particularly to such heat pumps of a rotary or centrifugal design, and to methods of operating said heat pumps.

[0002] Absorption cycle heat pumps comprise the following components: evaporator, absorber, generator, condenser and optionally a solution heat-exchanger; and are charged with a suitable working mixture in the fluid phase. The working mixture comprises a volatile component and an absorbent therefor.

[0003] In absorption cycle heat pumps, a high temperature source of heat, so-called high-grade heat, and a low temperature source of heat, so-called low-grade heat, deliver heat to the heat pump, which then delivers (or ejects) the sum of the heat input from both sources at an intermediate temperature.

[0004] In operation of conventional heat absorption cycle heat pumps, a working mixture which is rich in a volatile component (which mixture is hereinafter referred to for convenience as "Mixture R") is heated in the generator, under pressure, by high-grade heat such that vapour of the volatile component is generated and a working mixture which is less rich or lean in the volatile component is produced (which mixture is hereinafter referred to for convenience as "Mixture L").

[0005] In known single stage heat pumps the aforesaid vapour of the volatile component from the generator is condensed in the condenser, at the same high pressure, with the evolution of heat and the formation of liquid volatile component. The liquid volatile component is passed through an expansion valve, to reduce the pressure thereof, and thence to an evaporator. In the evaporator, the aforesaid liquid accepts heat from a low temperature source of heat, typically air or water at ambient temperature, and evaporates. The resulting vapour of the volatile component passes to an absorber where it is absorbed in Mixture L with the re-formation of Mixture R and evolution of heat. The Mixture R is then transferred to the vapour generator and hence completes the cycle. Many variations on this process are possible; for example the heat pump may have two or more stages, where vapour from the volatile component evaporated by the first mentioned (primary) vapour generator condenses in an intermediate condenser which is thermally coupled to supply heat to an intermediate vapour generator which creates further volatile component vapour to condense in the first mentioned (primary) condenser.

[0006] Where we wish to emphasize the physical state of the volatile component we shall, for convenience, refer to it as 'WC' (when it is in the gas or vapour state) or 'LVC' (when it is in the liquid state). The volatile component may otherwise be referred to as the refrigerant, and the mixtures L and R as absorbent fluid. In the particular example given, the refrigerant is water and the absorbent fluid is a hydroxide solution comprising alkali metal hydroxides as described in EP-A-208427.

[0007] U.S. Patent No. 5,009,085 discloses an earlier rotary heat pump. There are various problems associated with a heat pump of the kind described in U.S. Patent 5,009,085, and various aspects of the present invention seek to overcome or at least mitigate these problems.

[0008] In heat pumps such as those described in U. S. Patent 5,009,085, there is a risk of catastrophic failure if the working fluid should crystallize or otherwise experience restricted flow. For this reason the heat pump is usually operated with the maximum solution concentration set well away from the crystallization condition, and determined by the desire to avoid crystallization rather than to provide maximum efficiency. We have developed a modification which initiates corrective action when the onset of crystallisation is detected, thus allowing safe operation close to the crystallization condition.

[0009] US: A-3410704 describes a stationary heat pump arrangement in which, in the case of a blockage at the inlet to the heat exchanger, the hot strong fluid backs up a tube until the level reaches a limited capacity line through which the backed up fluid passes towards a sensor which responds to an increase in temperature to restrict or close a valve controlling flow of steam into a generator heat exchanger.

[0010] US: A-4485638 describes a stationary heat pump arrangement in which a goose-neck bypass system operates to pass strong solution from the generator to the absorber if the level of the strong solution builds up beyond a selected level.

[0011] Accordingly in one aspect, this invention provides an absorption cycle heat pump comprising a rotary assembly including a vapour generator, a condenser, an evaporator and an absorber so interconnected as to provide a cyclic fluid flow path for a working fluid comprising a refrigerant and an absorbent, and having at least one site prone to at least one of crystallization and high viscosity of the absorbent, wherein said heat pump includes means directly responsive to an increase in local back pressure upstream of said site indicative at the onset of crystallization of absorbent in the working fluid, or the onset of high viscosity, to initiate means to effect at least one of:-

preventing further crystallization,
re-dissolving crystallized material, and
reducing said viscosity.

[0012] The area most prone to crystallization or flow restriction is normally sited in the absorbent fluid flow path into the absorber from the solution heat exchanger, which is at its lowest temperature and highest concentration.

[0013] The means for preventing may comprise clearance means for increasing the temperature and/or reducing the concentration of absorbent in the working fluid at or adjacent said crystallisation site. For example a

stream of fluid may be diverted at least temporarily to increase the temperature of the flow past said crystallisation site either directly or indirectly by thermal exchange. This may be activated by detecting the local pressure upstream of the crystallization site.

[0014] In one method, where absorbent fluid passing from the vapour generator to the absorber gives up heat to absorbent fluid passing in the opposite direction via a solution heat exchanger, a portion of the absorbent fluid from the path from the generator to the absorber, which will have a relatively high temperature, is diverted to be introduced into the return flow from the absorber back to the generator. In this way, the temperature of the return flow is increased which raises the temperature of the flow upstream of the crystallization site, thereby dissolving or reducing the viscosity of the liquid at said site.

[0015] This diversion may be achieved by providing a pressure dependent control such as a valve or a weir between the two flows, whereby said introduction is initiated when the back pressure caused by the onset of crystallization or unacceptably high viscosity exceeds a preset threshold.

[0016] The features described above may, where the context allows, be used in single or multistage heat pumps either alone or in combination with each other.

[0017] The invention also extends to a method of operating absorption cycle heat pumps in accordance with claim 7. Thus in a further aspect this invention provides a method of operating an absorption cycle heat pump, said heat pump comprising a rotary assembly including a vapour generator, a condenser, an evaporator and an absorber so interconnected as to provide a cyclic fluid flow path for a working fluid comprising a refrigerant and an absorbent, and having a least one site prone to at least one of crystallization and high viscosity of the absorbent, which method comprises monitoring the working fluid to detect an increase in local back pressure upstream of a site prone to crystallisation indicative of at least one of the onset of crystallization of absorbent in the working fluid or the onset of high viscosity and, on detecting such an increase, initiating preventive measures for effecting at least one of:-

preventing further crystallization,
re-dissolving crystallised material, and
reducing said viscosity.

[0018] Preferably, said initiating step comprises diverting a stream of fluid (e.g. warm working fluid) at least temporarily to increase the temperature adjacent a site prone to crystallization or increased viscosity. Where the working fluid comprises a crystallizable absorbent liquid, said initiating step may comprise at least temporarily reducing the concentration of absorbent liquid adjacent or upstream of a site prone to crystallisation.

[0019] By way of example only, an embodiment of heat pump in accordance with this invention will now be described in detail, with various modifications thereof, reference being made to the accompanying drawings, in which:-

Figure 1 is a system diagram of a two stage heat pump in accordance with this invention, with non-limiting temperatures and pressures given merely by way of illustration;

Figure 2 is a schematic side view of a heat pump in accordance with this invention, showing the principle components of the heat pump, but with several interconnections, components and the working fluid omitted for clarity;

Figure 3 is an example of damping device for use with a scoop pump in a modification of the heat pump shown in the Figures;

Figure 4 is another example of damping device for use with a scoop pump;

Figure 5 is a schematic diagram illustrating a possible pressure sensitive flow control for use in reducing the possibility of crystallization in the absorbent fluid flow between the generator and the absorber, and

Figure 6 is an idealised diagram representing the optimal solution concentrations and the temperatures of the other elements of the heat pump for a set evaporator temperature and two different temperature lifts.

[0020] Referring to Figures 1 and 2, the illustrated embodiment of heat pump comprises a hermetically sealed unit 10 which rotates with a shaft 12 and which defines a high pressure space 14, an intermediate pressure space 16, and a low pressure space 18. The terms "high", "intermediate" and "low" refer to the pressures therein when the heat pump is operating. The interior of the heat pump is emptied of air during manufacture. The high pressure space 14 is bounded at the left hand side as viewed by a wall acting as a vapour generator 20, which is heated externally by a burner 22. At its other side, the high pressure space 14 is bounded by a wall which defines a condenser 24 on its high pressure surface, and an intermediate vapour generator 26 on the other surface, and which also defines the left hand end of the intermediate pressure space 16. A further wall 27 is located within the high pressure space 14, disposed between the vapour generator 20 and the condenser 24 and defining a feed chamber 28, for collecting fluid from the generator OFF pipe 30, as to be described below.

[0021] The intermediate pressure space 16 is separated from the low pressure space by a partition wall 32, and contains a condenser twin coil 34, and first and second solution heat exchangers 36 and 38. The low pressure space 18 contains an absorber coil 40 and an evaporator twin coil 42.

[0022] In operation a water-rich mixture of water and alkalimetal hydroxides is scooped from a common generator ON/OFF trough 44 by a generator ON scoop

pump inlet 46 and discharged from the generator ON delivery pipe 48 onto the vapour generator 20 to spread over the surface. A proportion of the volatile component (water) evaporates and passes to the condenser 24. The remaining, water-lean mixture 'L' collects in the generator ON/OFF trough 44. The generator ON scoop pump inlet 46 forms part of a fluid weighted scoop pump assembly 50 which will be described in more detail below. A generator OFF scoop pump inlet 52 is part of the same assembly but is disposed radially inwardly of the generator ON scoop pump inlet 46. The generator OFF scoop pump discharges the mixture 'L' into the annular feed chamber 28, whence the mixture passes via a pipe (not shown) into the cooling pass of the first solution heat exchanger 36 where it gives up heat to mixture 'R' flowing in the other side and about to return to the generator ON/OFF trough 44 from the intermediate vapour generator 26 (see Figure 1). Having passed through the cooling pass of the first solution heat exchanger 36, the mixture 'L' then passes through the cooling pass of the second solution heat exchanger 38, where it gives up heat to fluid on the other side which is flowing from the vapour absorber 40 to the intermediate vapour generator 26. From the cooling pass, the mixture 'L' passes through a flow restrictor 54 (see Figure 1), and thence into an annular absorber ON trough 56 formed on the absorber side of the partition wall 32. From here, the mixture is collected by the scoop pump inlet 58 of an absorber ON scoop pump and discharged via delivery pipe 60 onto the coil of the absorber 40, where it absorbs volatile component from the evaporator 42.

[0023] The mixture which is now water-rich collects in an absorber OFF trough 62, whence it is pumped to a feed chamber 64 formed as an annular trough on the partition wall 32, radially inwardly of the absorber ON trough 56, via an absorber OFF scoop pump inlet 66 and delivery pipe 68. The absorber ON and OFF scoop pumps are part of a common assembly 65.

[0024] From the feed chamber 64, the water-rich mixture passes to the heating pass of the second solution heat exchanger 38 where it is heated, and then delivered to an intermediate generator ON trough 70. From there the fluid is collected by the inlet 72 of an intermediate generator ON scoop pump and discharged by the delivery pipe 74 towards the centre of the intermediate generator 26 where it receives heat from the intermediate condenser 24 on the other surface of the same wall. A portion of the volatile component is evaporated by the intermediate vapour generator 26 and passes to the coil condenser 34 of the primary condenser. The liquid mixture leaving the intermediate vapour generator 26 collects in an OFF trough 76 whence it is scooped by the inlet 78 of an intermediate generator OFF pump and supplied via a delivery pipe 80 to the heating pass of the first solution heat exchanger 36, where it is heated and then returns to the common generator ON/OFF trough 44. The intermediate generator ON and OFF scoop pumps form part of a common assembly mounted on the shaft 12. For clarity the flow connections to and from the solution heat exchangers have been omitted.

[0025] Looking now at the flow cycle for the volatile component, a proportion of the volatile component is evaporated in the high pressure space 14 as the mixture passes over the vapour generator 20, and the VVC condenses on the surface of the intermediate condenser 24. The condensed LVC is then passed to the primary condenser 34 in the intermediate pressure space 16 via a throttle 82 (see Figure 1).

[0026] From the primary condenser 34, the LVC passes via a further throttle 84 to an evaporator ON trough 86 in the low pressure space 18. Here the fluid is collected by the scoop pump inlet 88 of an evaporator ON pump 89 and discharged via the delivery pipe 90 onto the evaporator coil 42. From there the evaporated VVC passes to the absorber coil 40, where it is absorbed back into the mixture and then follows the mixture path. A second scoop pump inlet 92 restricts the level of LVC in trough 86 by pumping excess LVC into a container 102 which is associated with the evaporator ON pump, and which has a bleed drain orifice 94 and an overflow 96.

[0027] The right hand end of the shaft 12 is divided into passageways 103, 105 for providing a flow path for coolant fluid, e.g. water, which passes down the centre of the shaft, circulates around the twin coils of the primary condenser 34 and then around the absorber coil 40 and then exits the shaft. The flow through the condenser coils 34 starts at the inner part of the left hand coil as viewed, travels spirally outwards, then back inwards and out. In the absorption coil 40, the flow starts at the outermost part of the coil and travels spirally inwards.

[0028] Likewise a chilled fluid water circuit (not shown) supplies and collects chilled water from the evaporator coils 42.

[0029] Having described the overall arrangement, certain particular improvements or modifications will now be described.

CONTROL OF ABSORBENT MIXTURE FLOW RATE

[0030] The flow rate of the absorbent mixture around the heat pump is controlled by a flow restrictor 54 in the line between the second solution heat exchanger 38 and the absorber ON trough 56, associated with the vapour absorber 40.

[0031] The flow restrictor 54 may be an orifice, capillary, vortex or nozzle, and the flow rate through the restrictor 54 is determined by the pressure acting across it. Thus the flow rate depends on the relevant pressures rather than being set by the generator OFF pump capacity as previously. The flow rate will therefore be modulated by the pressure difference between the high and low pressure spaces 14, 18, and also the manometric head difference between the free surface in the feed chamber 28, and that in the absorber ON trough 56. The flow rate of absorbent will automatically increase as the

pressure difference increases between spaces 14 and 18. The characteristics of the restrictor 54, the design pressure difference between spaces 14 and 18, and the disposition and capacity of the feed chamber 28 and the trough 56 are selected to provide the desired variation of flow rate with operating conditions.

[0032] The minimum flow rate at the target operating condition is normally set by crystallization considerations, but any margin above this reduces the efficiency of the heat pump due to increased losses in the solution heat exchangers. Thermodynamically the best efficiency will be obtained when the absorbent concentration is just sufficient to support the temperature lift demanded of the cycle. Under these circumstances various considerations will dictate the mass flow rate of absorbent required. In systems using water refrigerant and inorganic salt absorbent the minimum flow, at a given temperature lift, may be constrained by the maximum solution concentration that can be tolerated before the onset of crystallization.

[0033] Figure 6 shows a typical idealised fluid characteristic where it can be seen that at an absorber and condenser temperature of 58°C, mixture at a given solution concentration can absorb refrigerant at 4°C. This solution concentration can be seen in the ideal cycle shown to produce a generator temperature of 200°C. When the absorber and the condenser temperatures are lowered to 35°C then it can be seen if the solution concentration is lowered to suit the new conditions then the generator temperature drops to 117°C.

[0034] This means that for a given mass flow of absorbent around the cycle the heat losses through the heat exchangers would also be expected to drop. Additionally such a lower concentration would also substantially reduce the crystallization temperature permitting a lowering of the flow rate (and hence a higher solution concentration excursion). The control system described elsewhere in this application provides for both this automatic concentration adjustment and adjustment of the mass flow to further improve performance.

FLUID-WEIGHTED SCOOP PUMPS

[0035] The common generator ON and OFF pump assembly 50, comprises a bob container 98 suspended from the shaft 12 by a journal bearing, and fed with liquid from the common trough 44 by an inlet pipe 100, which is radially inwards of inlet pipes 46 and 52. In operation this means that part of the fluid inventory normally held in the generator ON trough is held in the bob container, making a substantial contribution to the stationary mass of the pump assembly 50. Also, on shut down, a substantial amount of fluid would normally collect in the trough 44 and be displaced by the bob mass for the pump assembly. With the illustrated arrangement, when the pump is stationary, fluid remains in or passes into the bob container 98 via the inlet pipe 100, thus reducing the level of fluid in the trough and increasing the mass of the pump assembly. These features contribute to a greatly reduced drag on start up.

[0036] Likewise, the evaporator ON pump 89 comprises a bob container 102, which acts as a bob weight, and furthermore as a running buffer for refrigerant as to be discussed below.

CONTROL OF ABSORBENT FLUID CONCENTRATION

[0037] The arrangement of Figure 2, is configured so that the concentration of absorbent is adjusted automatically in accordance with the rate of absorntion of vaporised volatile component by the absorber 40. The evaporator ON pump 89 includes a pipe inlet 92 which pumps any excess liquid volatile component into the container 102. This LVC is removed from circulation and thus causes the proportion of absorbent in the circulating mixture to increase as the contents of container 102 increase. There is a controlled bleed via orifice 94 back into the trough 86. The maximum concentration of absorbent is limited by providing the container 102 with an overflow 96 which discharges into the absorber OFF trough 62. In this way, the absorbent concentration is self-regulating by storing a variable amount of LVC in the container 102, and the cycle requirements previously discussed may be met.

SCOOP PUMP DAMPING

[0038] Referring to Figure 3, there is shown a schematic form of a damping device for a scoop pump, which may be used for any or all of the scoop pumps in the arrangement of Figure 2. The pump 104 is mounted by a journal on the shaft 12 and comprises a body 106 and a scoop pipe inlet 108. Below the scoop pump inlet 108 is provided a drag element, in the form of a dummy inlet 107. Here, even when the scoop pump inlet is clear of the fluid level, the dummy inlet 107 is still immersed and thus provides an important damping facility as the scoop pump inlet leaves or re-enters the fluid.

[0039] In an alternative arrangement shown in Figure 4, several parts are similar and are given like reference numerals. However, below the journal there is provided a curved track 110, which is not concentric with shaft 12, and which defines a constraining passage for a mass 112. The mass is constrained so that it may move along the track when the body is tilted about the shaft, tending to restore the body to its equilibrium state, but with some friction/stiction so that the kinetic energy of the pendulum movement is rapidly dissipated. The track many take may forms. This arrangement is particularly effective where there is no adjacent stationary structure to act as a reference

CRYSTALLIZATION PREVENTION

[0040] As previously discussed, it is desirable for cy-

cle efficiency to operate as close to the crystallization limit as possible, but the effects of crystallization can be catastrophic. Accordingly, as can be seen in Figures 1 and 5, a flow diversion scheme is set up so that, as soon as the onset of crystallization is detected, mixture from the vapour generator 20 may be diverted at 112, upstream of the second solution heat exchanger 38, to join at 114 the flow from the vapour absorber 40 about to enter the second solution heat exchanger 38. This causes the temperature of the flow entering the second solution heat exchanger 38 from the vapour absorber 40 to increase, which increases the temperature of the flow from the second solution heat exchanger to the vapour absorber, past the region 116 where crystallization is most likely to start.

[0041] In the arrangement of Figure 5, the flow diversion is controlled by a pressure sensitive weir 118. In normal operation the pressure difference between points 112 and 114 is insufficient to overcome the head defined by the weir and so there is no flow. However when crystallization begins in region 116, the back pressure at point 112 is sufficient to cause fluid to flow to point 114. In this arrangement, the flow restrictor 54 may advantageously be re-located upstream of the flow diversion point 112.

[0042] Various other flow control devices could be used and, for convenience Figure 1 indicates the control means as a control valve 120. This feature may also be used to deal with working fluids prone to undesirable increases in viscosity tending to obstruct flow.

COMMON ON/OFF GENERATOR TROUGH

[0043] It will be noted that the various scoop pipe inlets 46, 52 and 100 take fluid from the same trough 44, but that the generator ON inlet pipe 46 is deeper in the trough than the other two. This ensures that at start up and other extreme conditions, the generator ON pump has preferential access to fluid in the trough, thus reducing the possibility of the generator surface running dry.

HEAT EXCHANGERS

[0044] In the arrangement of Figure 1, to provide enhanced heat and mass transfer, the heat exchangers making up the condenser 34, the absorber 40 and the evaporator 42, comprise spirals of metal tubing (typically copper) of flattened cross-section. The spirals are generally closed with adjacent turns touching or close to each other. We have found that the corrugated surface defined by the tubing provides increased surface area and an excellent surface for heat and mass transfer.

HYDROGEN CONTAMINATION

[0045] In the illustrated embodiments, at least one of the sealed spaces 14, 16, 18 contains an element 114 of hydrogenatable polymer material which is loaded with a catalyst and which has a high affinity for hydrogen molecules, and which in use scours the internal atmosphere of hydrogen to avoid contamination of the absorbent fluid on the absorber.

[0046] A typical combination of polymer and catalyst is a styrene-butadiene triblock copolymer PS-PB-PS such as Kraton D1102 from Shell Chemical Company and an Iridium based catalyst such as the Crabtree Catalyst [Ir(COD)(py)(tcyp)]PF_6 (COD - 1.5-cyclooctadiene; py -pyridene, tcyp - tricyclohexylphosphine). An element of such material of volume 300ml may be sufficient to absorb free hydrogen for a period of several years.

PRESSURE RELIEF

[0047] The arrangement of Figure 2 also includes pressure relief valves 122, 124 between the high and intermediate, and intermediate and low pressure spaces 14 and 16, and 16 and 18 respectively. The pressure relief valves provide a smooth modulation of flow rate with pressure when they open, thus allowing the heat pump to have an extended operating range, operating as a single stage heat pump when the pressure differential across the pressure relief valves exceeds the valve opening pressure, and returning to two stage operation when the pressure difference returns to normal.

Claims

1. An absorption cycle heat pump comprising a rotary assembly including a vapour generator (20;26), a condenser (24;34) an evaporator (42) and an absorber (40) so interconnected as to provide a cyclic fluid flow path for a working fluid comprising a refrigerant and an absorbent, and having at least one site (116) prone to at least one of crystallisation and high viscosity of the absorbent, **characterised in that** said heat pump includes means directly responsive to an increase in local back pressure upstream of said site indicative of the onset crystallisation of absorbent in the working fluid or the onset of high viscosity, to initiate means to effect at least one of:-

   preventing further crystallisation,
   re-dissolving crystallised material, and
   reducing said viscosity.

2. An absorption cycle heat pump according to Claim 1, which comprises clearance means (120) for increasing the temperature and/or reducing the concentration of absorbent in the working fluid at or adjacent a site (116) prone to crystallisation or increased viscosity.

3. An absorption cycle heat pump according to Claim 2, including means (118) for diverting a stream of fluid at least temporarily to increase the temperature of the flow past said site (116) prone to crystallisation or increased viscosity.

4. An absorption cycle heat pump according to Claim 2 or 3, wherein, in use, absorbent fluid passing from the vapour generator (20) to the absorber (40) gives up heat to absorbent fluid passing in the opposite direction via a solution heat exchanger (38), and said heat pump includes means (118) for diverting a portion of the absorbent fluid from the path (112) from the generator to the absorber to be introduced into the return flow (114) from the absorber (40) back to the vapour generator (20), thereby increasing temperature of the flow upstream of the site (116) prone to crystallization or increased viscosity.

5. An absorption cycle heat pump according to Claim 4, wherein said diversion means comprises a pressure dependent control such as a valve or a weir (118) between the two flows, whereby said diversion is initiated when the back pressure caused by the onset of crystallization or high viscosity exceeds a preset threshold.

6. An absorption cycle heat pump according to any of Claims 3 to 5, wherein said diversion means is operable to divert coolant fluid from the condenser (34) to the evaporator (42), thereby to raise the evaporation temperature and cause an increased amount of refrigerant to evaporate and be taken up by the absorbent, resulting in a temporary decrease in concentration of absorbent in the working fluid and an increase in temperature of the working fluid in the crystallisation region.

7. A method of operating an absorption cycle heat pump, said heat pump comprising a rotary assembly including a vapour generator (20;26), a condenser (24;34) an evaporator (42) and an absorber (40) so interconnected as to provide a cyclic fluid flow path for a working fluid comprising a refrigerant and an absorbent, and having at least one site (116) prone to at least one of crystalisation and high viscosity of the absorbent, which method comprises monitoring the working fluid to detect an increase in local back pressure upstream of said site indicative of at least one of the onset of crystallisation of absorbent in the working fluid or the onset of high viscosity and, on detecting such an increase, initiating preventive measures for effecting at least one of:-

preventing further crystallisation,
re-dissolving crystallised material, and
reducing said viscosity.

Patentansprüche

1. Absorptionszykluswärmepumpe mit einer Kreisprozeßanordnung, welche folgendes umfaßt, einen Dampfgenerator (20; 26), einen Kondensor (24, 34), einen Verdampfer (42) und einen Absorber (40), welche derart miteinander verbunden sind, daß ein zyklischer Fluidströmungsweg für ein Arbeitsfluid, welches ein Kältemittel sowie ein Absorptionsmittel enthält, zur Verfügung steht, und mit wenigstens einem Ort (116), an dem das Absorptionsmittel zur Kristallisation und/oder Hochviskosität neigt,
dadurch gekennzeichnet,
daß die Wärmepumpe ein Mittel umfaßt, welches direkt auf eine Erhöhung eines lokalen Gegendrukkes bzw. Rückstaus stromauf dieses Ortes, was eine Kristallisation des Absorptionsmittels im Arbeitsfluid oder eine Hochviskosität anzeigt, anspricht, um Mittel auszulösen, welche wenigstens eine der folgenden Wirkungen haben:

Verhindern einer weiteren Kristallisation,
wieder in Lösung bringen des kristallisierten Werkstoffes, und
Reduzieren der Viskosität.

2. Absorptionszykluswärmepumpe nach Anspruch 1, **dadurch gekennzeichnet, daß** ein Freigabemittel (120) zum Erhöhen der Temperatur und/oder zum Reduzieren der Konzentration des Absorptionsmittels in dem Arbeitsfluid bei oder nahe des Ortes (116), an dem das Absorptionsmittel zur Kristallisation oder erhöhter Viskosität neigt, vorgesehen ist.

3. Absorptionszykluswärmepumpe nach Anspruch 2, **dadurch gekennzeichnet, daß** Mittel (118) zum wenigstens temporären Zuführen eines Fluidstromes vorgesehen sind, um die Temperatur des Stromes nach dem Ort (116), an dem das Absorptionsmittel zur Kristallisation oder erhöhter Viskosität neigt, zu erhöhen.

4. Absorptionszykluswärmepumpe nach Anspruch 2 oder 3, **dadurch gekennzeichnet, daß** vom Dampfgenerator (20) zum Absorber (40) strömendes Absorptionsmittelfluid Wärme an in entgegengesetzter Richtung über einen Lösungswärmetauscher (38) strömendes Absorptionsmittelfluid abgibt und daß die Wärmepumpe Mittel (118) zum Ableiten eines Teils des Absorptionsmittelfluids vom Strömungsweg (112) vom Dampfgenerator zum Absorber zum Einleiten in den Rückfluß (114) vom Absorber (40) zurück zum Dampfgenerator (20) umfaßt, was die Temperatur der Strömung stromauf des Ortes (116), an dem das Absorptionsmittel zur Kristallisation oder erhöhter Viskosität neigt, erhöht.

5. Absorptionszykluswärmepumpe nach Anspruch 4, **dadurch gekennzeichnet, daß** das Ableitmittel eine druckabhängige Steuerung, wie beispielsweise ein Ventil oder ein Wehr (118), zwischen zwei Strömungen umfaßt, wodurch die Ableitung erfolgt, wenn der durch die Kristallisation oder die hohe Viskosität bedingte Rückstau einen vorbestimmten Schwellwert übersteigt.

6. Absorptionszykluswärmepumpe nach einem der Ansprüche 3 bis 5, **dadurch gekennzeichnet, daß** das Ableitmittel derart ausgebildet ist, daß es Kühlfluid vom Kondensor (34) zum Verdampfer (42) ableitet, wodurch eine erhöhte Verdampfungstemperatur dazu führt, daß eine größere Menge Kühlmittel verdampft und im Absorber aufgenommen wird, was zu einer vorübergehenden Verringerung der Konzentration des Absorptionsmittels in dem Arbeitsfluid und einer Erhöhung der Temperatur des Arbeitsfluides im Kristallisationsbereich führt.

7. Verfahren zum Betrieb einer Absorptionszykluswärmepumpe mit einer Kreisprozeßanordnung, welche folgendes umfaßt, einen Dampfgenerator (20; 26), einen Kondensor (24, 34), einen Verdampfer (42) und einen Absorber (40), welche derart miteinander verbunden sind, daß ein zyklischer Fluidströmungsweg für ein Arbeitsfluid, welches ein Kältemittel sowie ein Absorptionsmittel enthält, zur Verfügung steht, und mit wenigstens einem Ort (116), an dem das Absorptionsmittel zur Kristallisation und/oder Hoch-Viskosität neigt, wobei das Verfahren ein Überwachen des Arbeitsfluides zum Feststellen einer Erhöhung eines lokalen Rückstaus stromauf des Ortes, was eine Kristallisation des Absorptionsmittels im Arbeitsfluid und/oder eine Hochviskosität anzeigt, beinhaltet, wobei nach Feststellen einer derartigen Erhöhung wenigstens eine der folgenden vorbeugenden Maßnahmen ausgelöst wird:

Verhindern einer weiteren Kristallisation,
wieder in Lösung bringen des kristallisierten Werkstoffes, und
Reduzieren der Viskosität.

Revendications

1. Pompe à chaleur à cycle d'absorption comprenant un ensemble rotatif incluant un générateur de vapeur (20 ; 26), un condenseur (24 ; 34), un évaporateur (42) et un absorbeur (40) interconnectés de façon à assurer une voie d'écoulement de fluide cyclique pour un fluide de travail comprenant un réfrigérant et un absorbant, et ayant au moins un site (116) prédisposé à au moins l'une parmi la cristallisation et la viscosité élevée de l'absorbant, **caractérisée par le fait que** ladite pompe à chaleur comprend des moyens directement sensibles à une augmentation de la contre-pression locale en amont dudit site, indicative du début de la cristallisation de l'absorbant dans le fluide de travail ou du début de la viscosité élevée, pour faire démarrer des moyens pour effectuer au moins l'une des actions suivantes :

- empêcher une nouvelle cristallisation ;
- redissoudre la matière cristallisée ; et
- réduire ladite viscosité.

2. Pompe à chaleur à cycle d'absorption selon la revendication 1, qui comprend des moyens de dégagement (120) pour augmenter la température et/ou réduire la concentration de l'absorbant dans le fluide de travail au niveau ou au voisinage d'un site (116) prédisposé à la cristallisation ou à la viscosité augmentée.

3. Pompe à chaleur à cycle d'absorption selon la revendication 2, comprenant des moyens (118) pour dévier un courant de fluide au moins temporairement pour augmenter la température de l'écoulement passant ledit site (116) prédisposé à la cristallisation ou à la viscosité augmentée.

4. Pompe à chaleur à cycle d'absorption selon l'une des revendications 2 ou 3, dans laquelle, lors de l'utilisation, du fluide absorbant passant du générateur de vapeur (20) à l'absorbeur (40) cède de la chaleur au fluide absorbant passant dans la direction opposée par l'intermédiaire d'un échangeur de chaleur par solution (38), et ladite pompe à chaleur comprend des moyens (118) pour dévier une partie du fluide absorbant de la voie (112) du générateur à l'absorbeur pour être introduite dans l'écoulement de retour (114) de l'absorbeur (40) en retour au générateur de vapeur (20), augmentant de cette façon la température de l'écoulement en amont du site (116) prédisposé à la cristallisation ou à la viscosité augmentée.

5. Pompe à chaleur à cycle d'absorption selon la revendication 4, dans laquelle ledit moyen de déviation comprend une commande dépendante de la pression telle qu'une soupape ou un déversoir (118) entre les deux écoulements, ce par quoi ladite déviation est démarrée lorsque la contre-pression provoquée par le début de la cristallisation ou de la viscosité élevée dépasse un seuil pré-établi.

6. Pompe à chaleur à cycle d'absorption selon l'une quelconque des revendications 3 à 5, dans laquelle ledit moyen de déviation est actionnable pour dévier du fluide réfrigérant du condenseur (34) à l'évaporateur (42), pour augmenter de cette façon la

température d'évaporation et amener une quantité accrue de réfrigérant à s'évaporer et à être reprise par l'absorbant, conduisant à une diminution temporaire de la concentration de l'absorbant dans le fluide de travail et à une augmentation de température du fluide de travail dans la région de cristallisation.

7. Procédé pour faire fonctionner une pompe à chaleur à cycle d'absorption, ladite pompe à chaleur comprenant un ensemble tournant comprenant un générateur de vapeur (20 ; 26), un condenseur (24 ; 34), un évaporateur (42) et un absorbeur (40) interconnectés de façon à assurer une voie d'écoulement de fluide cyclique pour un fluide de travail comprenant un réfrigérant et un absorbant, et ayant au moins un site (116) prédisposé à au moins l'une parmi la cristallisation et la viscosité élevée de l'absorbant, lequel procédé comprend la surveillance du fluide de travail pour détecter une augmentation de la contre-pression locale en amont dudit site, indicative d'au moins l'un parmi le début de la cristallisation de l'absorbant dans le fluide de travail ou le début de la viscosité élevée et, lors de la détection d'une telle augmentation, le démarrage de mesures préventives pour effectuer au moins l'une des actions parmi :

- empêcher une nouvelle cristallisation ;
- redissoudre la matière cristallisée ; et
- réduire ladite viscosité.

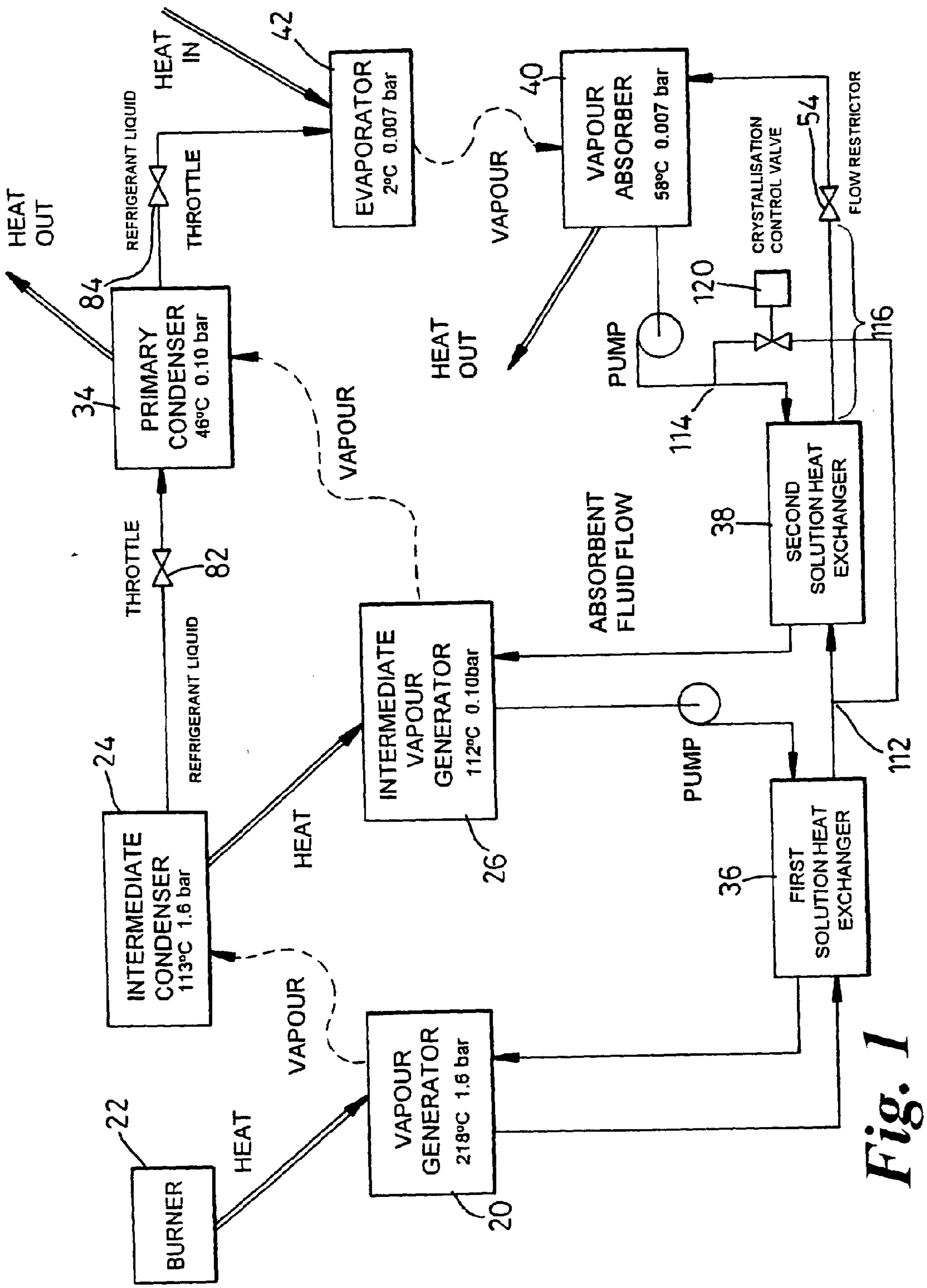
BURNER
22
HEAT
VAPOUR GENERATOR 218ºC 1.6 bar
20
VAPOUR
INTERMEDIATE CONDENSER 113ºC 1.6 bar
24
HEAT
INTERMEDIATE VAPOUR GENERATOR 112ºC 0.10bar
26
REFRIGERANT LIQUID
THROTTLE
82
VAPOUR
PRIMARY CONDENSER 46ºC 0.10 bar
34
84
HEAT OUT
REFRIGERANT LIQUID
THROTTLE
EVAPORATOR 2ºC 0.007 bar
42
HEAT IN
VAPOUR
VAPOUR ABSORBER 58ºC 0.007 bar
40
HEAT OUT
PUMP
120
CRYSTALLISATION CONTROL VALVE
54
FLOW RESTRICTOR
116
114
ABSORBENT FLUID FLOW
SECOND SOLUTION HEAT EXCHANGER
38
PUMP
112
FIRST SOLUTION HEAT EXCHANGER
36

Fig. 1

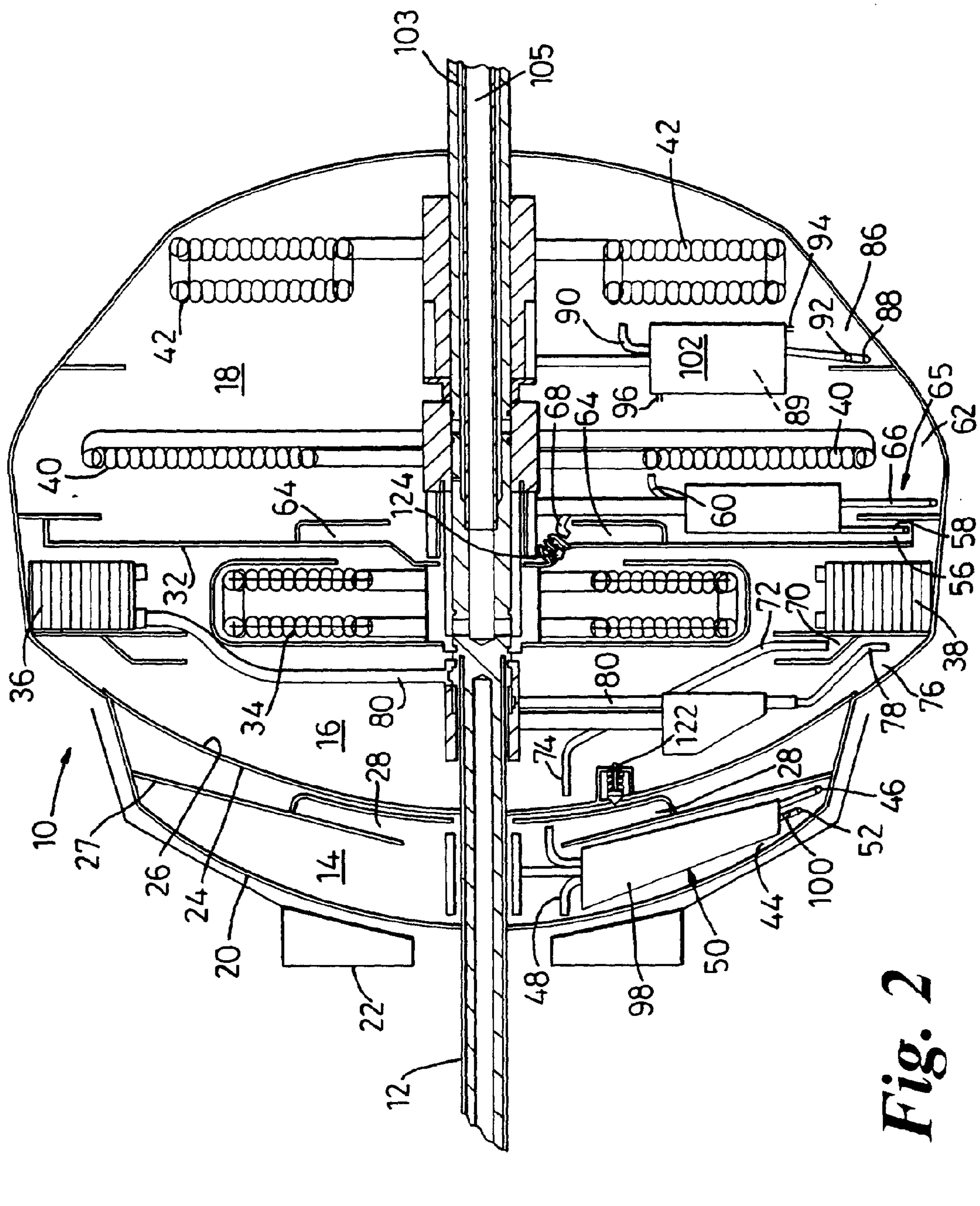
103
105
42
94
86
90
92
88
102
89
96
65
62
66
60
58
56
40
18
68
64
124
32
36
34
72
70
38
80
16
122
78
76
74
28
46
52
10
27
26
24
14
100
44
50
20
22
48
98
12

Fig. 2

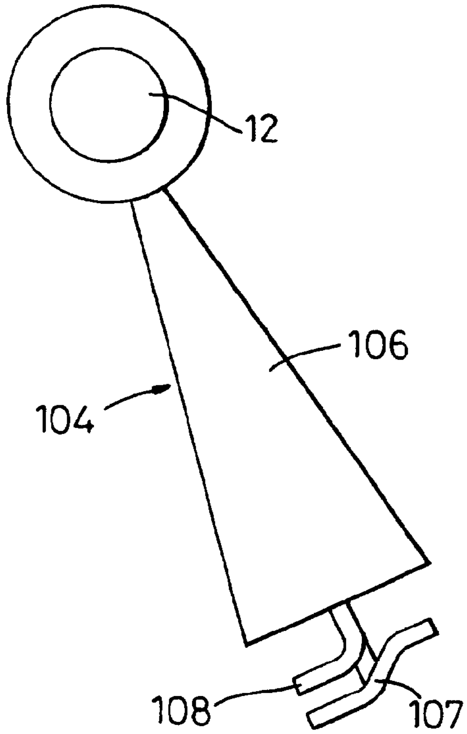

Fig. 3

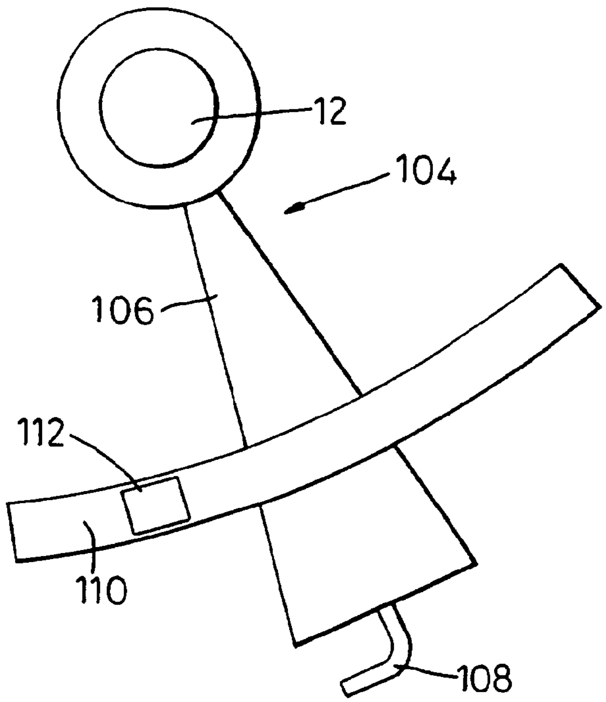

Fig. 4

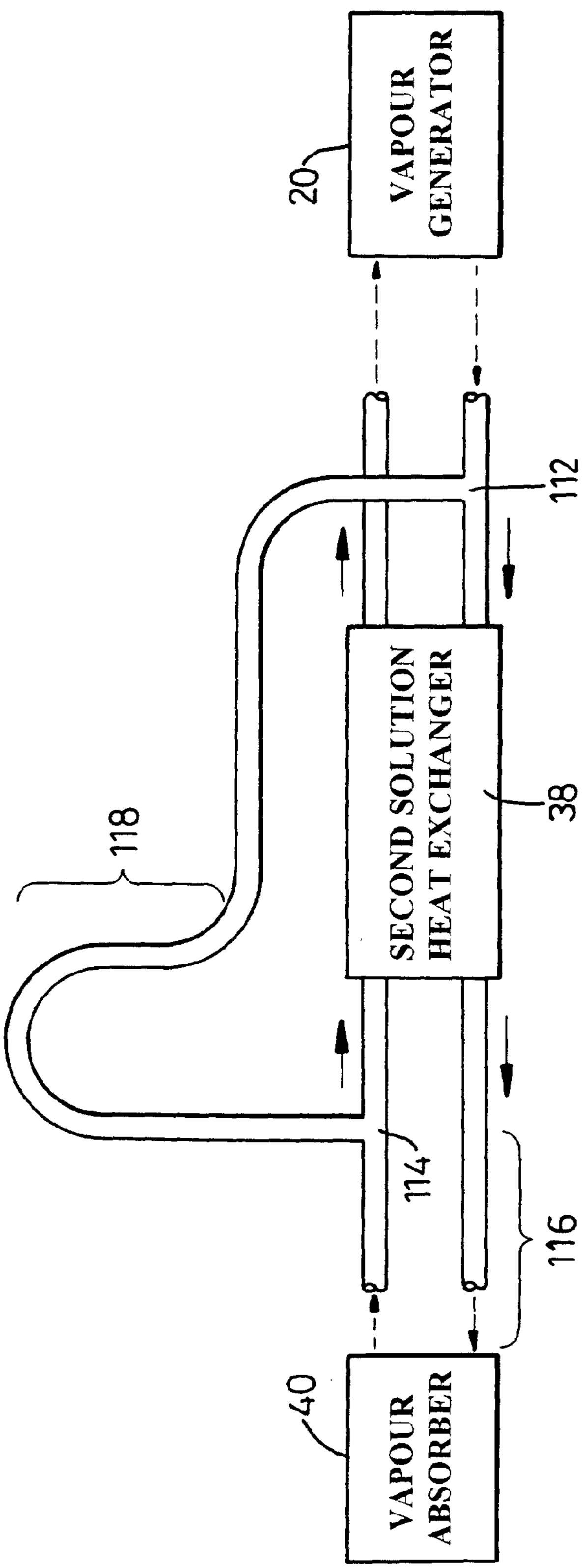
VAPOUR GENERATOR
20
112
118
SECOND SOLUTION HEAT EXCHANGER
38
114
116
VAPOUR ABSORBER
40

Fig. 5

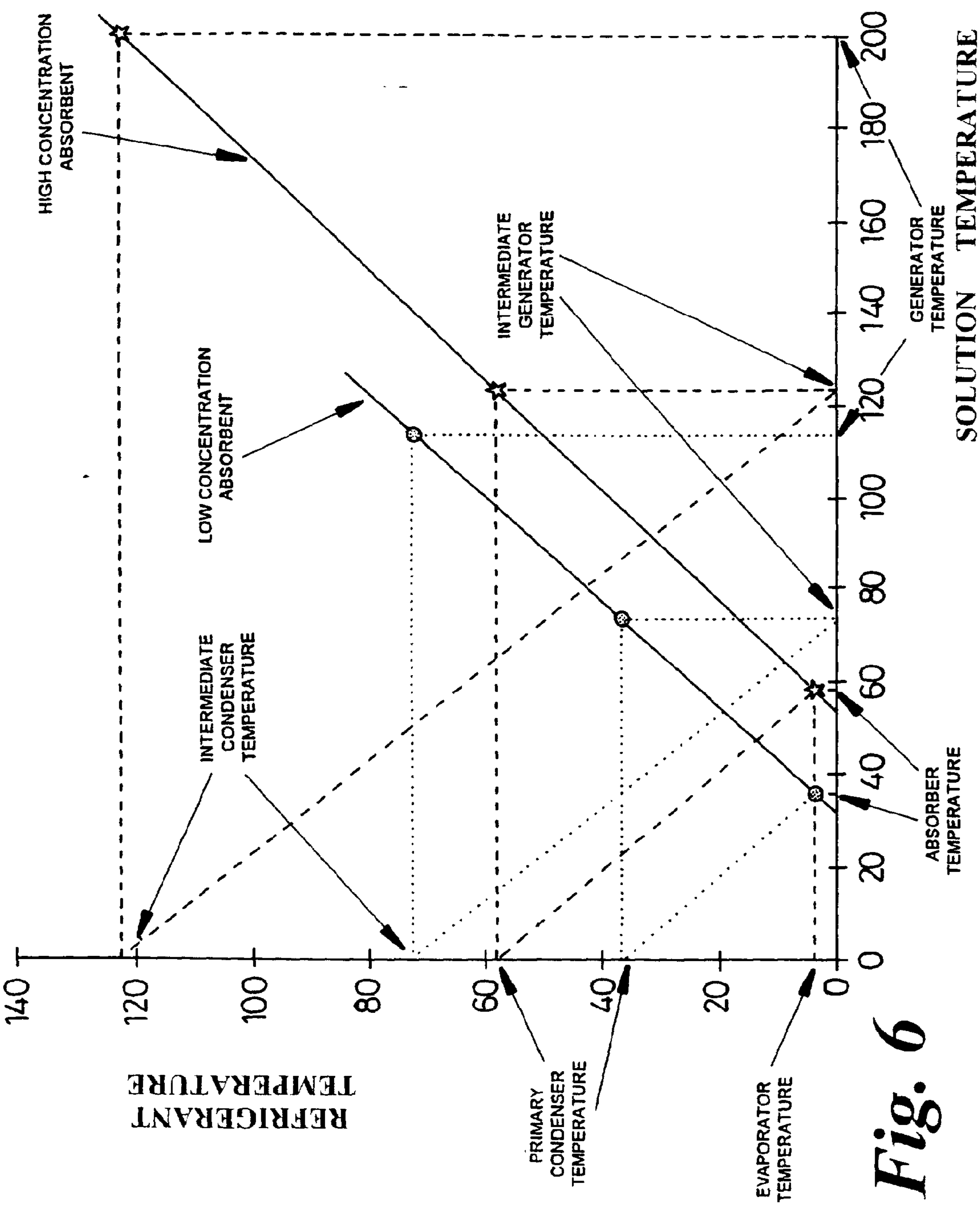
HIGH CONCENTRATION ABSORBENT
LOW CONCENTRATION ABSORBENT
INTERMEDIATE GENERATOR TEMPERATURE
GENERATOR TEMPERATURE
INTERMEDIATE CONDENSER TEMPERATURE
ABSORBER TEMPERATURE
PRIMARY CONDENSER TEMPERATURE
EVAPORATOR TEMPERATURE
REFRIGERANT TEMPERATURE
SOLUTION TEMPERATURE
0
20
40
60
80
100
120
140
160
180
200

Fig. 6